WHAT IS CLAIMED IS:

1. A distortion measurement method comprising:

a first formation step of repeating, m x n times, shot exposure of arranging first marks on a photosensitive substrate via a reticle and a projection optical system in M rows and N columns at a predetermined column interval and a predetermined row interval, thereby forming first marks in M x m rows and N x n columns on the photosensitive substrate, M and m being natural numbers which are relatively prime, N and n being natural numbers which are relatively prime, and M > m and N > n;

a second formation step of repeating, M x N times, shot exposure of arranging second marks on the photosensitive substrate via the reticle in m rows and n columns at the predetermined column interval and the predetermined row interval, thereby forming second marks in M x m rows and N x n columns on the photosensitive substrate, the first and second marks formed in the first and second formation steps forming M x m x N x n overlay marks;

a measurement step of measuring misalignment amounts of the first and second marks for each of the M x m x N x n overlay marks; and

a calculation step of calculating a distortion amount of the projection optical system on the basis of the misalignment amounts measured in the measurement

step.

2. The method according to claim 1, wherein

letting p_x be the predetermined column interval and p_y be the predetermined row interval,

in the first step, shot exposure is repeated at a shot interval of $p_x \times N$ in a row direction and a shot interval of $p_y \times M$ in a column direction, and

in the second step, shot exposure is repeated at a shot interval of $p_x \times n$ in the row direction and a shot interval of $p_y \times m$ in the column direction.

3. The method according to claim 1, wherein in the calculation step, a distortion amount is calculated for a ξth overlay mark formed from an ith first mark of a kth shot in the first formation step and a jth second mark of an lth shot in the second formation step by solving $2 \times M \times m \times N \times n$ simultaneous equations obtained by substituting misalignment amount measurement values $\delta_x(\xi)$ and $\delta_y(\xi)$ in X and Y directions that are measured in the measurement step into

$$\delta_x(\xi) = dx_1(i) - dx_2(j) + ex_1(k) - ex_2(l) - Y_1(i)\theta_1(k) + Y_2(j)\theta_2(l)$$

$$\delta_y(\xi) = dy_1(i) - dy_2(j) + ey_1(k) - ey_2(l) + X_1(i)\theta_1(k) - X_2(j)\theta_2(l)$$

where

$dx_1(i)$, $dy_1(i)$: misalignment amounts of the ith first mark

$dx_2(j)$, $dy_2(j)$: misalignment amounts of the jth second mark

$ex_1(k)$, $ey_1(k)$, $\theta_1(k)$: alignment errors of the kth shot in the first formation step

$ex_2(l)$, $ey_2(l)$, $\theta_2(l)$: alignment errors of the lth shot in the second formation step

$X_1(i)$, $Y_1(i)$: coordinates of the ith first mark within the shot

$X_2(j)$, $Y_2(j)$: coordinates of the jth second mark within the shot.

4. The method according to claim 3, wherein when the simultaneous equations are solved in the calculation step, a respective sum of $dx_2(j)$, $dy_2(j)$, $ex_1(k)$, $ey_1(k)$, $\theta_1(k)$, $ex_2(l)$, $ey_2(l)$, and $\theta_2(l)$ is assumed to be 0, and a respective sum of $X_2(l) \times ex_2(l)$, $Y_2(l) \times ey_2(l)$, $Y_2(l) \times ex_2(l)$, and $X_2(l) \times ey_2(l)$ is assumed to be 0, for all the overlay marks.

5. The method according to claim 1, wherein the misalignment amount includes a misalignment amount between respective barycentric positions of the first and second marks which constitute the overlay mark.

6. A distortion measurement apparatus comprising:

control means for controlling an exposure apparatus so as to form M x m x N x n overlay marks on a photosensitive substrate by repeating, m x n times, shot exposure of arranging first marks on the photosensitive substrate via a reticle and a projection

optical system in M rows and N columns at a predetermined column interval and a predetermined row interval to form first marks in M x m rows and N x n columns on the photosensitive substrate, and by repeating, M x N times, shot exposure of arranging second marks on the photosensitive substrate via the reticle in m rows and n columns at the predetermined column interval and the predetermined row interval to form second marks in M x m rows and N x n columns on the photosensitive substrate, M and m being natural numbers which are relatively prime, N and n being natural numbers which are relatively prime, and M > m and N > n;

measurement means for measuring misalignment amounts of the first and second marks for each of the M x m x N x n overlay marks; and

calculation means for calculating a distortion amount of the projection optical system on the basis of the misalignment amounts of the first and second marks which are measured for each of the M x m x N x n overlay marks.

7. The apparatus according to claim 6, wherein

letting p_x be the predetermined column interval and p_y be the predetermined row interval,

said control means repeats shot exposure at a shot interval of p_x x N in a row direction and a shot interval of p_y x M in a column direction to form the

first marks in the M x m rows and the N x n columns, and repeats shot exposure at a shot interval of $p_x \times n$ in the row direction and a shot interval of $p_y \times m$ in the column direction to form the second marks in the M x m rows and the N x n columns.

8. The apparatus according to claim 6, wherein said calculation means calculates a distortion amount for a ξth overlay mark formed from an ith first mark of a kth shot by said first formation means and a jth second mark of an lth shot by said second formation means by solving 2 x M x m x N x n simultaneous equations obtained by substituting misalignment amount measurement values $\delta_x(\xi)$ and $\delta_y(\xi)$ in X and Y directions that are measured by said measurement means into

$$\delta_x(\xi) = dx_1(i) - dx_2(j) + ex_1(k) - ex_2(l) - Y_1(i)\theta_1(k) + Y_2(j)\theta_2(l)$$

$$\delta_y(\xi) = dy_1(i) - dy_2(j) + ey_1(k) - ey_2(l) + X_1(i)\theta_1(k) - X_2(j)\theta_2(l)$$

where

$dx_1(i)$, $dy_1(i)$: misalignment amounts of the ith first mark

$dx_2(j)$, $dy_2(j)$: misalignment amounts of the jth second mark

$ex_1(k)$, $ey_1(k)$, $\theta_1(k)$: alignment errors of the kth shot by said first formation means

$ex_2(l)$, $ey_2(l)$, $\theta_2(l)$: alignment errors of the lth shot

by said second formation means

$X_1(i)$, $Y_1(i)$: coordinates of the ith first mark within the shot

$X_2(j)$, $Y_2(j)$: coordinates of the jth second mark within the shot.

9. The apparatus according to claim 8, wherein when said calculation means solves the simultaneous equations, a respective sum of $dx_2(j)$, $dy_2(j)$, $ex_1(k)$, $ey_1(k)$, $\theta_1(k)$, $ex_2(l)$, $ey_2(l)$, and $\theta_2(l)$ is assumed to be 0, and a respective sum of $X_2(l) \times ex_2(l)$, $Y_2(l) \times ey_2(l)$, $Y_2(l) \times ex_2(l)$, and $X_2(l) \times ey_2(l)$ is assumed to be 0, for all the overlay marks.

10. The apparatus according to claim 6, wherein the misalignment amount includes a misalignment amount between respective barycentric positions of the first and second marks which constitute the overlay mark.

11. An exposure apparatus comprising:

exposure means for transferring an image on a reticle onto a wafer by exposure light; and

storage means for generating and storing a correction value for exposure processing on the basis of a distortion amount obtained by executing a distortion measurement method defined in claim 1,

wherein the correction value is reflected in exposure processing by said exposure means.

12. A device manufacturing method comprising steps of:

installing manufacturing apparatuses for various processes including an exposure apparatus defined in claim 11 in a semiconductor manufacturing factory; and

manufacturing a semiconductor device by a plurality of processes using the manufacturing apparatuses.

13. A method comprising:

a first exposure step of exposing each of first shot regions on a substrate to a plurality of first marks aligned at a predetermined interval via a master and a projection optical system;

a second exposure step of exposing each of second shot regions on the substrate to a plurality of second marks aligned at the predetermined interval via the master and the projection optical system, the first and second shot regions being so arranged as to make positions of a plurality of transferred first and second marks on the substrate correspond to each other, the plurality of transferred first and second marks being formed due to said first and second exposure step respectively, and number of the transferred first marks in the first shot region being larger than number of the transferred second marks in the second shot region; and

a calculation step of calculating a distortion amount of the projection optical system based on a positional difference measured for the transferred

first and second marks which correspond to each other.

14. A storage medium storing a program which causes a computer to execute a method, the method comprising:

a first exposure step of exposing each of first shot regions on a substrate to a plurality of first marks aligned at a predetermined interval via a master and a projection optical system;

a second exposure step of exposing each of second shot regions on the substrate to a plurality of second marks aligned at the predetermined interval via the master and the projection optical system, the first and second shot regions being so arranged as to make positions of a plurality of transferred first and second marks on the substrate correspond to each other, the plurality of transferred first and second marks being formed due to said first and second exposure step respectively, and number of the transferred first marks in the first shot region being larger than number of the transferred second marks in the second shot region; and

a calculation step of calculating a distortion amount of the projection optical system based on a positional difference measured for the transferred first and second marks which correspond to each other.

15. An exposure apparatus comprising:

an exposure unit which exposes a substrate to a master pattern via a projection optical system; and

a control unit which executes a method defined in claim 13 to obtain a distortion amount of the projection optical system, and controls an exposure process by said exposure unit based on the obtained distortion amount.

16. A device manufacturing method comprising:

providing an exposure apparatus defined in claim 15; and

manufacturing a device using the exposure apparatus.